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EUROPEAN PATENT APPLICATION

21 Application number: 89300514.0

51 Int. Cl. 4: **A61K 7/13**

22 Date of filing: 19.01.89

30 Priority: 31.03.88 US 175565

43 Date of publication of application:
04.10.89 Bulletin 89/40

84 Designated Contracting States:
AT BE CH DE ES FR GB GR IT LI LU NL SE

71 Applicant: Bristol-Myers Company
345 Park Avenue
New York New York 10154(US)

72 Inventor: Schultz, Thomas M.
25, Dogwood Court
Highland Mills, N.Y. 10930(US)
Inventor: Brown, Keith C.
59, Douglas Road
New Canaan Connecticut 06840(US)
Inventor: Murphy, Bryan P.
94, Hillside Lane
Monroe Connecticut 06468(US)
Inventor: Mayer, Alice A.
37, Juniper Road
Bethel Connecticut 06801(US)
Inventor: Lim, Mu-III
31, Mayflower Drive
Trumbull Connecticut 06611(US)

74 Representative: Baillie, Iain Cameron et al
c/o Langner Parry Isartorplatz 5
D-8000 München 2(DE)

54 The use of N-substituted-5,6-dihydroxyindoles as a hair coloring agent.

57 The use of N-substituted-5,6-dihydroxyindoles in solution as a hair dyeing agent in combination with the pre-treatment of the hair to be dyed with a solution comprising the water soluble salt of various metals is also provided. This yields hair colors from light golden to light reddish brown to dark auburn to black.

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THE USE OF N-SUBSTITUTED-5, 6-DIHYDROXYINDOLES AS A HAIR COLORING AGENT

This invention relates to the use of N-substituted 5, 6-dihydroxyindoles as a hair coloring agent.

Background of the Invention

Over the past thirty years the prior art has disclosed the use of dihydroxyindoles as hair dyes. The major thrust of the teachings of the prior art is that 5,6-dihydroxyindole (DHI) is a metabolite of DOPA and is intimately related to the natural mammalian pigment eumelanin. Various prior art references teach that a natural looking dyeout can be obtained using solutions of 5,6-dihydroxyindole. It is known, however, that use of this dye agent alone requires long dyeout times and therefore a variety of accelerators has been employed to hasten the dye formation.

It is also known that DHI is difficult to synthesize requiring exceptional care in its preparation. The compound is unstable in air and rapidly decomposes to other materials which are ineffective as hair colorants. Therefore, commercial production of DHI has been lacking and this may be the major reason why no hair coloring products utilize dihydroxyindoles.

In the prior art that teaches the use of dihydroxyindoles as hair colorants, commonly the dye solution is of such a nature that the oxidants used as accelerators must be kept separate from the dihydroxyindoles, and the two parts are typically mixed together immediately before use. However, dyeing methods are described wherein the dye/oxidant combination can be applied sequentially.

Specifically, U.S. patent No. 2,934,396 teaches that DHI in an acidic solution should be applied to the hair followed by a second application of an amine (alkaline) base or an amine base with IO_3 , IO_4 , persulfate, CuSO_4 or MnSO_4 to initiate the dyeout. The range of brown shades is claimed but dyeing times are long and from about 45 minutes for light shades

to about 90 minutes for the darker browns. The desirability of keeping the DHI solution at acidic pH is a result of the inherent instability of the compound. One method of overcoming this difficulty in the handling of DHI has been taught in U.S. patent No. 3,194,734 where the more stable diacetate of DHI is converted to the free phenol with an alkalinizing agent immediately prior to use. Otherwise the alkaline DHI solution will spontaneously form particulate matter and become ineffective for dyeing hair.

G.B. 887,579 and U.S. patent No. 3,194,734 both teach that acidic to alkaline solutions of the 1-, 2-, or 3-methyl substituted dihydroxyindoles or combinations thereof color hair to a variety of brown shades depending upon the composition

mixture. In these cases the process involves applying first either an alkaline or acidic mixture of the methyl-5,6-dihydroxyindole to hair followed by contacting the hair with an oxidizing solution. Alternatively, immediately prior to use, the acidic indole solution is mixed with the alkaline oxidizing solution and then this mixture is applied to the hair. These patents claim that various light to dark brown dyeouts are obtained over about 40 to about 60 minutes.

Whereas the prior art teaches that DHI or its methylated derivatives dye hair dark brown to black in 60 to 90 minutes, the resulting color can be somewhat modulated by incorporating a metal-ion into the dye composition. Specifically it is taught in US 3,194,734 that applying a neutral to basic pH solution of the 5,6-dihydroxyindole and an oxidizing solution containing a metal salt, such as cobaltous acetate or silver nitrate will color the hair light brown to reddish brown. It is specifically taught that the solutions are to be made up fresh and then used immediately. Even with metal catalyst added to the dye mixture the dyeing time is still long.

A significant improvement in the prior art is taught in Dutch Patent NI 8304157A wherein hair is treated with a metal salt solution (salts of Co, Fe, Mn, Ti, Cu, Zn, Ta, Cr, Ni, Pd, Pt, Au, Mg, Cd, Br, Sn, Pb, or Bi) prior to application of an alkaline solution of DHI. Color formation in hair requires in this case only a few minutes. However, it should be noted that, although highly intense, the initial color imparted is achromatic.

We have now found that N-substituted dihydroxyindoles dye metal ion-pretreated hair to a wide range of cosmetically pleasing colors. The imparted colors are controlled by the nature of the metal ion, its concentration and pH of the dyeing composition.

Summary of the Invention

The present invention encompasses the use of N-substituted-5,6-dihydroxyindoles generally and more

particularly in an aerobic or alcoholic aqueous solution at pH 3 to pH 12, as a hair dyeing agent.

This invention also pertains to the use of N-substituted-5,6-dihydroxyindoles in combination with the pre-treatment of the hair with a metal salt which acts as an agent which both accelerates the transformation of the indoles to melanins and also determines the color of the dyed hair.

- 5 The present invention also includes the use of alkaline hydrogen peroxide applied after the dyeing of hair has been achieved in order to lighten the dyed hair to light golden blonde to light reddish brown shades.

10 Detailed Description of the Invention

The art of hair dyeing with melanin precursors such as DHI has been severely hindered by the instability of the dye. We were surprised to find that pH 3-12 solutions of N-substituted-5, 6-dihydroxyindoles were exceptionally stable and could be handled in the open air with no extraordinary precautions taken.

Furthermore, although their oxidation is slow, metal ion-pretreated hair is dyed a wide range of colors by N-substituted-5, 6-dihydroxyindoles within a few minutes.

This variety of colors is achieved simply by use of different metal salts. The color intensity can be further modulated by the concentration of the chosen metal salts and/or the pH of the color-forming reactions.

Preferably, it is the identity of the metal ion which is varied to change the color. For example, use of Cu(II) yields a black whereas Zn (II) gives a golden brown and Ag (I) yields a dark auburn. In the absence of metal ions the dyeing process is slow and the color product is a drab brown. But in the presence of a metal-ion a dramatic acceleration in the speed of the dyeing occurs and the total process is over in a few minutes.

Because the dyeing process does not require the use of the harsh oxidation chemicals frequently incorporated in commercial permanent hair coloring products, hair is not oxidatively damaged and feels full and smooth. Moreover both the metal salts and dihydroxyindoles may be applied from conditioning shampoos further contributing to a pleasant feel of the hair.

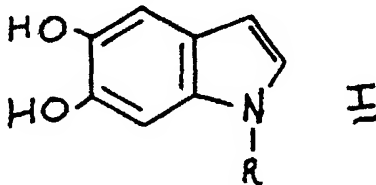
30 Although the hair can be either treated first with the indole dye mixture followed by the metal salt or in the reverse order, the results obtained by a metal-ion pretreatment are generally superior.

In addition, the imparted color can be further modulated or substantially removed by treatment of the dyed hair with oxidants such as H₂O₂ or reductants such as sulfites, etc.

Another significant advantage to the use of N-substituted-5,6-dihydroxyindole is their significantly easier synthesis. Whereas the synthesis route to DHI requires many steps, some of which involve extremely harsh chemical reagents, the N-substituted materials are readily synthesized from the corresponding 3,4-dihydroxy-phenethylamine precursors, and quite unexpectedly, the N-substituted-5, 6-dihydroxyindoles so produced are extremely stable.

Consequently, they do not require storage under nitrogen or in poly-alcohols, as has been taught for DHI itself.

By way of specific examples, we show the preparation of derivatives of N-substituted-5,6-dihydroxyindoles (I) which demonstrates the ease of their preparation.

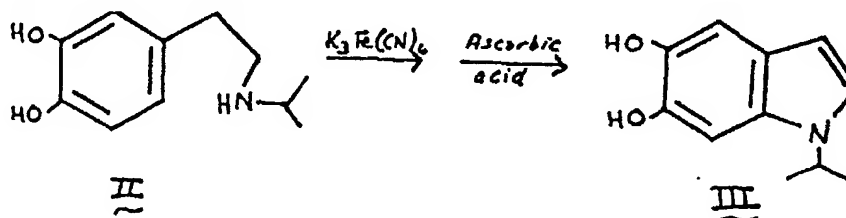


The following is intended to illustrate without limitation thereto various known routes of synthesis of various N-substituted-5,6-dihydroxyindoles useful in the present invention.

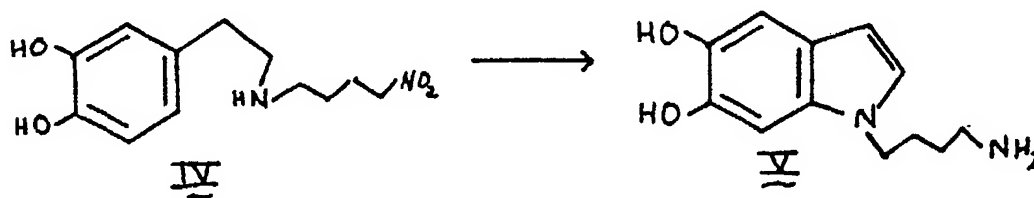
(a) Synthesis by cyclization of a Dopamine derivative:

The suitable 3,4-dihydroxy-N-substituted phenethylamine material is converted by oxidative cyclization followed by chemical reduction to the N-substituted-dihydroxyindole as per the method for preparation of N-methyl-5,6-dihydroxyindoles from epinephrine described by G.L. Mattok and R. A. Heacock in the Canadian Journal of Chemistry, Volume 42, p.484 (1964), but the invention is not to be limited by the exact use of solvent and oxidants detailed therein.

For example, N-isopropyl-3,4-dihydroxyphenethylamine (II) can be oxidized by an alkaline ferricyanide solution followed by reduction with ascorbic acid to give N-isopropyl-5,6-dihydroxyindole (III):

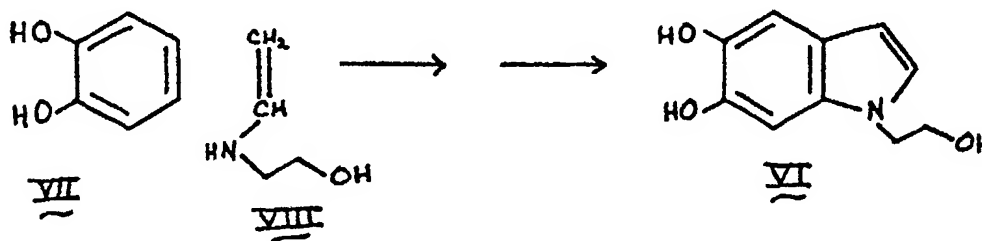


Similarly N-(4-aminobutyl)-5,6-dihydroxyindole (V) can be obtained from 3,4-dihydroxy-N-(4-nitrobutyl)-phenethylamine (IV);



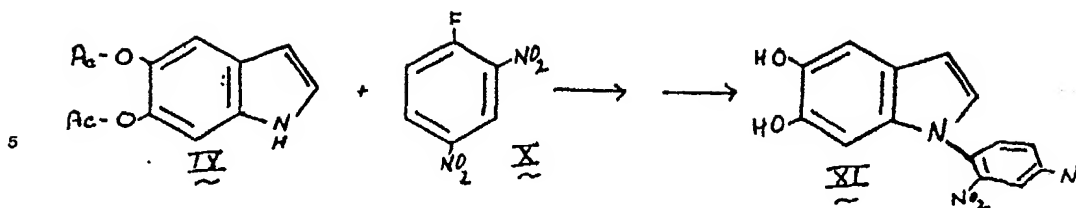
(b) Synthesis by condensation of a benzenoid compound and a nitrogen containing compound.

An alternate synthetic procedure is available by the methods described by A. Reissert in Chemische Berichte, Volume 30, page 1030 (1897) and C.D. Nenitzescu in Bulletin of the Chemistry Society of Rumania, Volume 11, page 37 (1929) where the indole is produced upon the condensation of a benzenoid radical with an appropriate N-containing material. For example, N-(2-hydroxyethyl)-5,6-dihydroxyindole (VI) can be obtained upon oxidative coupling of catechol (VII) with N-vinyl ethanolamine (VIII) followed by reduction.



(c) Synthesis by addition of indole to an aryl compound

A final example is the direct addition of the indole to an aryl or benzyl halide or azide to give the aryl or arylalkyl N-substituted-5,6-dihydroxyindole. Specifically, 5,6-diacetoxy-indole (IX) is reacted with fluoro-2,4-dinitrobenzene (X) to give after hydrolysis of the acetate radicals, N-(2,4-dinitrophenyl)-5,6-dihydroxyindole (XI);



The N-substituents useful in the present invention will be those derived from structure I where the N-substituent, R, is alkyl, alkoxy, hydroxyalkyl, aminoalkyl, containing 1 to about 8 carbon atoms in the moiety or a substituted or unsubstituted aryl wherein aryl substituents are OH, NH₂, alkyl, alkoxy, or NO₂.

The preferred indoles are those in which R is C₁ to C₈ alkyl, C₁-C₈ alkoxy, C₁-C₈ hydroxyalkyl, or C₁-C₈ aminoalkyl, nitroaryl, or aminoaryl wherein the aryl groups have 1 to 3 substituents. Substituents on the aryl groups may be nitro, amino, alkoxy, or hydroxy and dinitro, diamino, or dihydroxyl.

EXAMPLES

20 Alkaline solutions of metal salts were prepared in amine (for example, monoethanolamine) buffers while those at lower pH were adjusted with citric acid.

N-substituted indole were dissolved in aqueous alcohols (ethanol, propanol etc.) The pH of these solutions were adjusted either with ethanolamine or citric acid.

25 The following examples are listed to demonstrate, but not limit, the scope of this invention. Examples II through IX illustrate the color modulation of dyeouts from N-methyl-5, 6-dihydroxyindole attained on metal-ion pretreated hair.

Example I:

30 Blended grey hair was treated with a 1% solution of N-methyl-5,6-dihydroxyindole at pH 8.5 for 50 minutes. A light brown color was produced.

Example II:

35 Blended grey hair was treated with a pH 9 solution of 1.0% CuSO₄ for 5 minutes at ambient temperature, rinsed, and then exposed to a pH solution of N-methyl-5,6-dihydroxyindole (1% wt/wt for 5 minutes. The hair was dyed very dark grey with yellow tones.

Example III:

45 The method of Example II was repeated, but the N-methyl-5, 6-dihydroxyindole solution was at pH 3 resulting in a dark charcoal grey dyeout.

Example IV:

50 The method of Example II was repeated, but the solution of N-methyl-5, 6-dihydroxyindole solution was at pH 12. The hair color was black.

Example V:

55 Blended grey hair was treated with 0.1% Fe₂(SO₄)₃ solution at pH 6 for 5 minutes rinsed and then soaked in a pH 8.5 solution of 1% (wt/wt) N-methyl-5,6-dihydroxyindole for 5 minutes to give a grey-brown

color.

Example VI:

Blended grey hair was treated with a pH 5.5 0.1% solution of $\text{Mn}(\text{OAc})_2$ for 5 minutes, rinsed, and then soaked in a 1% (wt/wt) solution of N-methyl-5,6-dihydroxyindole for 5 minutes to give a light grey-brown dyeout.

Example VII:

Blended grey hair was treated with 0.1% AgNO_3 at pH 5 for 5 minutes and then in a 1% N-methyl-5,6-dihydroxyindole solution at pH 6 for 5 minutes. The hair was dyed dark auburn-brown.

Example VIII:

The method of Example VII was repeated, using a 0.001% AgNO_3 solution which yielded a silvery light brown.

Example IX:

Blended grey hair was treated with a 0.1% (wt/wt) in $\text{Zn}(\text{OAc})_2$ solution at pH 6 for 5 minutes, rinsed, and then with a 1% (wt/wt) N-methyl-5,6-dihydroxyindole solution at pH 9 to give a golden brown dyeout in 5 minutes.

Examples X through XIII. are given to demonstrate the narrower range of colors attainable upon pretreatment with the indole and post-treating with the metal salt solution.

Example X:

Blended grey hair was soaked in a pH 6 solution of N-methyl-5,6-dihydroxyindole (1% wt/wt) for 15 minutes, rinsed, and then treated for 5 minutes in a pH 8 solution of 1.0% CuSO_4 to give a dark grey-brown dyeout with yellow hues.

Example XI:

The method of Example V was repeated, but the order of soakings was reversed to the indole first, then in a pH 6 0.1% $\text{Fe}_2(\text{SO}_4)_3$ solution for 5 minutes to yield a light brown dyeout.

Example XII:

The method of Example VI was repeated but the order of treatments was reversed to give a dark brown dyeout.

Example XIII:

The method of Example VII was repeated but the order of treatment was reversed to give a dark auburn dyeout. Example XIV through XVI detail the use of other N-substituted 5, 6-dihydroxyindoles found effective in coloring the hair durably.

Example XIV:

Blended grey hair was treated with a pH 9 solution of 1.0% CuSO₄ for 5 minutes, rinsed, and then exposed to a solution of 0.8% N-isopropyl-5,6-dihydroxyindole of pH 10 for 10 minutes to give a light brown color.

Example XV:

The method of Example XIV was repeated but the hair was first treated with 0.01% AgNO₃ at pH 8 for 5 minutes, rinsed, and then soaked in the 0.8% indole solution to give a light reddish brown color.

Example XVI:

Copper (II) pre-treated blended grey hair was immersed in a solution containing N-(2,4-dinitrophenyl)-5,6-dihydroxyindole (1% wt/wt at pH 9) for 15 minutes. The hair was dyed light brown with yellow tones.

Examples XVII through XXIV show the bleaching ability of both hydrogen peroxide and either bisulfite or thioglycollate in modulating or completely removing the color from N-substituted-5, 6-dihydroxyindole dyed blended grey hair.

Example	Indole Structure I, R =	Metal-ion	Bleaching Agent	Color Before	Color After
XVII	R = CH ₃	none	3% pH 9 H ₂ O ₂	light brown	golden brown
XVIII	R = CH ₃	Cu ⁺²	3% pH 9 H ₂ O ₂	dark grey	light golden brown
XIX	R = CH ₃	pretreatment Fe ⁺³	3% pH 9 H ₂ O ₂	grey-brown	very light golden brown
XX	R = CH ₃	pretreatment Mn ⁺²	3% pH 9 H ₂ O ₂	light grey brown	light strawberry blonde
XXI	R = CH ₃	Ag ⁺¹ pretreatment	3% pH 9 H ₂ O ₂ 10 minutes	dark auburn	medium reddish brown
XXII	R = CH ₃	Zn ⁺² pretreatment	3% pH 9 H ₂ O ₂ pretreatment	golden brown	pale golden brown
XXIII	R = isopropyl	Cu ⁺² pretreatment	3% pH 9 H ₂ O ₂	light brown	pale grey
XXIV	R = CH ₃	Cu ⁺² treatment	3% pH 9 H ₂ O ₂ 10 minutes	grey brown	medium grey
XXV	R = CH ₃	Cu ⁺² pretreatment	2% Bisulfite 10 minutes	dark grey	medium golden brown
XXVI	R = CH ₃	Cu ⁺² pretreatment	2% Thioglycollic acid 10 minutes	dark grey	light brown

It has been found that optimum results can be obtained when the N-substituted-5,6-dihydroxyindoles of the present invention are utilized in an aerobic aqueous solution or in an alcoholic aqueous solution at concentrations of from about 0.1% to 2.0% (wt/wt). Above this limiting concentration no more intensity in the color of the dyeout is observed. Preferably the solution utilized will have a concentration of from about 0.5% to about 1.0% (wt/wt), and most preferably it will have a concentration of 1.0% (wt/wt).

Further, it has now been determined that the solution of N-substituted-5,6-dihydroxyindole will achieve maximum effective coloration of the hair to be dyed when said solution is applied at a pH of from about pH 3 to about pH 12, preferably about pH 6 to about pH 11, most preferably about pH 7 to about 10.

The utilization of the aforementioned optimal solution of N-substituted-5,6-dihydroxyindole together with a pre-treatment of the hair with a composition comprising water soluble salts of, Ag⁺¹, Au⁺¹, Pb⁺², Pd⁺², Co⁺², Cu⁺², Bi⁺², Ni⁺², Mn⁺², Fe⁺³, Cr⁺⁴ or Ti⁺² in concentration of from 0.0001 to 2% (wt/wt) and at a pH of from pH 3 to pH 11 has been found to be most effective in achieving a variety

of desirable colorations in the dyed hair. Conventional water soluble counterions, e.g. sulfates, nitrates, and the like are useful.

The dyed hair may be subsequently treated with a solution of H_2O_2 in the concentration of from about 1% to about 6% (wt/wt), the preferred range is about 1% to about 3% (wt/wt), and at about pH 6 to about pH 10, with the preferred range of pH 8 to pH 10, for a period of 5 to 30 minutes to effect a rapid lightening of the hair to a light golden to light reddish brown coloration, as exemplified herein above.

While the invention has been described with reference to a number of embodiments, it will be apparent to one skilled in the art that there are numerous additional variations which properly fall within the range of this invention. Therefore, it should be understood that the foregoing embodiments and examples are set forth to illustrate the advantages to be achieved utilizing the present invention and should not be interpreted as limiting the scope of the invention.

Claims

1. A method for dyeing hair which comprises contacting the hair with a solution of a water soluble metal ion followed by contacting the hair with a solution of a N-substituted-5,6-dihydroxyindole, or in the reverse order, wherein the substituent on the nitrogen atom is selected from the group consisting of: C_{1-8} alkyl, hydroxyalkyl, aminoalkyl, aminoaryl, and nitroaryl, wherein the aryl group may bear from 1 to 3 substituents.

2. The method of Claim 1 wherein the water soluble salts are selected from the group consisting of salts of Cr, Ag, Au, Pb, Pd, Co, Cu, Ni, Bi, Mn, Fe, Ti, Sn, or Zn, and are applied in solution in concentrations of from about 0.001% to about 2.0% by weight at a pH of about pH 3 to about pH 11, prior to treating the hair with the said solution of N-substituted 5, 6-dihydroxyindole.

3. The method of Claim 1 wherein the solution of the N-substituted-5,6-dihydroxyindole is applied at about pH 3 to pH 12.

4. The method of Claim 2 wherein the hair to be dyed is subjected to steps comprising: (1) treatment with a composition comprising water soluble salts of Cr, Ag, Au, Pb, Pd, Co, Cu, Ni, Bi, Mn, Fe, Ti, Sn, or Zn, and are applied in solution in concentrations of from about 0.001% to about 2% by weight at a pH of about pH 3 to about pH 11, (2) subsequent treatment with said solution of N-substituted 5,6-dihydroxyindole at about pH 3 to about pH 12, either with or without rinsing of the first applied solution.

5. The method of claim 4 wherein the order of steps (1) and (2) is reversed.

6. The method of Claim 1 followed by the subsequent treatment of the hair with a solution of a bleaching agent, at a concentration of from about 1% to 6% at from about pH 6 to pH 11, for a period of 5 to 30 minutes to effect a lightening or removal of the coloration of the hair.

7. The method of Claim 6 wherein the bleaching agent is H_2O_2 .

8. The method of Claim 6 wherein the bleaching agent is a salt of SO_2 such as sodium or potassium bisulfate or a sulfhydryl compound such as thioglycolic acid or its potassium, sodium or ammonium salts.

9. The method of Claim 1, wherein the substituent in the N-substituted-5,6-dihydroxyindole is methyl, isopropyl, an aminophenyl, or a nitrophenyl wherein each benzene ring may also have from 1 to 3 substituents.

10. The method of Claim 1 wherein the N-substituted-5,6-di-hydroxyindole is N-methyl-5,6-dihydroxyindole.

11. The method of Claim 1 wherein the N-substituted-5,6-di-hydroxyindole is N-isopropyl-5,6-dihydroxyindole.

12. The method of Claim 1 wherein the N-substituted-5,6-di-hydroxyindole is N-(2,4-dinitrophenyl)-5,6-dihydroxyindole.

13. The method of Claim 1 wherein the N-substituted-5,6-di-hydroxyindole is N-(4-nitrophenyl)-5,6-dihydroxyindole.

14. The method of Claim 1 wherein the N-substituted-5,6-di-hydroxyindole is N(4-aminophenyl)-5,6-dihydroxyindole.